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Public perception of invasive plant species: assessing the impact of workshop activities to promote young students awareness

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Abstract

Invasive species are one of the main threats to biodiversity worldwide. Even though they are identified and recognized as such by the Portuguese law, the majority of the population is not yet aware of this problem. Aiming to increase awareness about biological invasions among young students, a workshop on Invasive Plant Species was organized at the Botanical Museum of the University of Coimbra. A total of 170 teenager students from five schools participated in the workshop. Three activities were prepared, focusing on: 1) identification of invasive plants, 2) competition between native and invasive plants and 3) control of invasive plants. One year later, questionnaires were sent to the participants, aiming to appraise workshop effectiveness, and this questionnaire revealed that these students know more about invasive plant species than a comparable group of students that did not participate in the workshop. The results clearly showed that practical informal education activities may be effective in raising public awareness. Questionnaires were essential to evaluate the knowledge acquired and retained by the students during the workshop.

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Key-words

Biodiversity, Biological Invasions, Environmental and scientific Education, Evaluation of practical activities, Questionnaires

1.Introduction

Every person is a potential vector of introduction and spread of Invasive Alien Species (IAS), and, on the other hand, everyone can play a major role in helping to control them and/or prevent their introduction, so effective public awareness is essential in the management of IAS.

The present work describes the activities and outreaches of a workshop projected to raise awareness about plant invasions among teenager students. An introductory short talk and practical activities were organized, aiming to catch students' attention and engage them with this subject. One year later, an evaluation was performed in order to appraise the true effectiveness of the workshop developed.

Why talk about invasive plant species in the Biodiversity context?

Many of the plants that we see nowadays were transported from their native ranges to other places in the world, being named exotic or alien plants. Some of these plants remain in the places where they were planted and grow without representing a threat to native species. However, others reproduce and disperse very quickly, maintaining self-sustaining populations at considerable distances from parent plants and becoming out of human control – these are invasive plants (Richardson *et al.*, 2000). Besides overcoming geographical barriers, invasive plants overcome biotic and abiotic barriers, maintaining self-reproductive populations. Once introduced, invasive plants have the ability to increase their populations and distributions without direct human intervention, and may threaten native ecosystems, food production and even human health and economy (Mooney *et al.*, 2005).

1
2 Biological invasions, not only by plant species but also by other organisms, are a
3
4 widespread and significant component of human-caused global-environmental change
5
6 (Mooney & Hobbs, 2000). Portuguese legislation (Decreto-Lei n.º 565/99, Ministério do
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8 Ambiente, 1999) lists about 400 exotic plant species as introduced in Portugal, and from
9
10 these classifies 30 as invasive. More recently, Almeida and Freitas(2006) and
11
12 Marchante *et al.*(2008a) referred over 550 exotic plant species introduced in mainland
13
14 Portugal including species that are considered as casuals, sub-spontaneous or invasive.
15
16 Even though IAS are considered one of the main threats to the world biodiversity
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18 (Mooney *et al.*, 2005; Richardson and Pyšek, 2006) and the problem is already
19
20 recognized by the Portuguese law, this subject is still unfamiliar to a large part of the
21
22 Portuguese population. The control and management of widespread invasive species is
23
24 extremely difficult and costly. Therefore, the best way to deal with invasive species is to
25
26 start by preventing their introduction (Commission of the European Communities,
27
28 2008), and for that raising public awareness is crucial.
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34 *Why invest in public awareness activities about IAS?*

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36 Together with limited resources and insufficient coordination among public
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38 administrations, lack of public awareness is recognized as contributing to the ineffective
39
40 management of IAS (Andreuet *et al.*, 2009). The higher level of public awareness about
41
42 invasive species could have huge implications in the improved success of biodiversity
43
44 management success (Fisher and van der Walt, 2007) and even in the prevention of IAS
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46 that can threat Europe biodiversity (Hulme *et al.*, 2009). On the other hand, the inability
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48 to correctly identify a particular species, or even distinguish between a native and an
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invasive species can have harmful consequences to the wildlife (Somaweera *et al.*, 2009).

Public awareness is therefore essential to draw different public's attention to the problem and the species involved. An educated public can help prevent introduction of IAS and to control IAS already present, which will contribute to mitigate the problems caused by these species. Conscious of the need to inform the public about this theme, a team gathering researchers from the Centre for Functional Ecology of the University of Coimbra (CFE) and from the Centre of Studies for Natural Resources, Environment and Society of Agrarian School of Coimbra (CERNAS) has been involved in promoting public awareness about invasive plants in Portugal (Marchante *et al.*, 2010) along with the scientific research on plant invasions. The activities developed have targeted different publics and include: 1) Field-work Projects to learn about invasive plant species and how to control them, 2) Training Courses about identification and control of invasive plants for professionals dealing with exotic plants, 3) a Web Page (www.ci.uc.pt/invasoras) about invasive plant species in Portugal, 4) Online questionnaires targeting several technical publics, and 5) Printed documentation aiming to create awareness about the problem and help to identify the most common and problematic invasive plants in Portugal (Marchante *et al.*, 2005a; Marchante *et al.*, 2005b; Marchante & Marchante, 2007; Marchante *et al.*, 2008a; Marchante *et al.*, 2008b).

Why develop practical workshops for young students?

In order to understand the relationships between people and IAS, an effective management that leads to minimize the spread of IAS must take in consideration the full spectrum of target publics (Reaser, 2001) as well as to be developed for specific target

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1
2 groups (Nuñez and Pauchard, 2010). However, young students are usually a less
3
4 common target of awareness concerning IAS when compared to general public
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6 (Bremner and Park, 2007; Somaweera *et al.*, 2009) or stakeholders (Andreuet *et al.*, 2009;
7
8 García-Llorente *et al.*, 2008). Although many efforts have been made, it is worthwhile
9
10 continuing to invest resources in public awareness and environmental education, since
11
12 only by doing so, perceptions and hence attitudes can change in time (de Poorter, 2001).
13
14 In fact, although students perceptions about biodiversity are in some cases low
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16 (Lindermann-Matthies and Bose, 2008), their active interest can be expressed if suitable
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18 didactic methods of communication are used (Strgar, 2007), which can reach successful
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20 impacts on the management of biodiversity (Fisher and van der Walt, 2007).
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24 Biological invasions are a topic that has only been recently, and briefly, included
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26 in school curricula in Portugal. Since this is a relatively recent concern of the scientific
27
28 community, it is not uncommon to find teachers that do not have a good knowledge on
29
30 the subject. Apprehensive about giving incorrect or much incomplete information to the
31
32 students, sometimes teachers choose not to refer the subject of biological invasions in
33
34 classes. However, young student population should not be elapsd when developing
35
36 awareness about invasive species in particular or biodiversity conservation in general,
37
38 since the messages retained at this age can be of great importance in the development of
39
40 environmental positive attitudes in the future.

41 42 43 44 *Why evaluate public awareness activities?*

45
46 Adequate evaluation of effectiveness is essential when communicating and raising-
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48 awareness, but it is frequently absent (O'Loughlin and Wegimont 2007). It is
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50 consensual that greater public awareness is necessary in relation to IAS (Colton, 1998;
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2 De Poorter, 2001; Hulme *et al.*, 2009; Lindermann-Mathies and Bose, 2008; Marchante *et*
3
4 *al.*, 2010; O'Loughlin and Wegimont, 2007; Reaser, 2001), however it is hard to find
5
6 references to the evaluation of the awareness activities developed and their effective
7
8 impact on the public, which is essential to enhance the ability to meet the goals
9
10 proposed (Krasny and Lee, 2002).

11
12
13 To be actually effective, public awareness must take in consideration local cases
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15 of IAS (Colt and Alpert, 1998), such as particular species that the public can easily find
16
17 in their everyday life. It is recognized that scale matters in public awareness: one person
18
19 can easily understand the consequences if activities affects him/her directly, but less if
20
21 the consequences affects the local community, the nation, the continent, or even the
22
23 globe (de Poorter, 2001).

24
25
26 In order to improve further public awareness initiatives, it was considered
27
28 essential to perform the evaluation of the workshop. For that, one year after the
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30 workshop, questionnaires about plant invasions were sent to participants aiming to
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32 appraise the effectiveness of the workshop that were developed during the workshop
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34 and the knowledge acquired and retained by the students.

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35 36 37 38 39 **2. Methodology**

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42 The “Invasive Plant Species – What are they? Where do they come from? Which
43
44 problems do they cause?” workshop was organized in the context of the Portuguese
45
46 National Science and Technology Week, running from 24th to 28th November 2008, and
47
48 took place in the Botanical Museum of the University of Coimbra. For five days, two
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50 sessions were offered each day, one in the morning and other in the afternoon (two
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52 hours each). Each session included a short introductory talk and three activities. The
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1
2 evaluation of the workshop was performed one year later through a questionnaire sent to
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4 the students that had participated in the workshop and also to a comparable group that
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6 did not attend the workshop.
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10 11 *Target-public*

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14 The workshop was addressed to students aged from 13 to 15 years old, which
15
16 corresponds to the 8th and 9th grade in Portugal. This target public was selected
17
18 considering the students' great potential to influence and raise public awareness both in
19
20 the school and also in the larger community. In addition, biological invasions were
21
22 recently included in the school curricula of these levels, although they are only briefly
23
24 discussed. Invitations were sent to all 183 public and private schools from the Regional
25
26 Direction of Education - Central Portugal (DREC). The first eight groups who
27
28 registered were selected to participate. Each group had up to 24 students. Participants
29
30 reached a total of 170 students from five different schools.
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36 *Invasive plant species Workshop*

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38 At the arrival, a brief introductory talk about invasive plants was given. Basic concepts,
39
40 such as native, exotic and invasive plant, and the problems caused by these species were
41
42 explained, some examples of the worse invasive plants in Portugal were given,
43
44 describing the key characteristics for identification, the region of origin, the problems
45
46 caused in the exotic range and their impacts on native biodiversity. Additionally, a list
47
48 of simple things that everybody can do to prevent plant invasions was shown and
49
50 discussed with the students. The presentation lasted about 20 minutes.
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2 Afterwards, the group was divided in two smaller groups, with up to 12 students.
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4 Two practical activities were prepared and both sub-groups took part in both, one at a
5
6 time. The activities focused on different issues of plant invasion, one about the
7
8 competition between native and invasive plants (activity 1) and the other about control
9
10 of invasive plants (activity 2). Finally, the students gathered again to learn how to
11
12 recognize some of the worse invasive plant species in Portugal (activity 3). All activities
13
14 were prepared using common and inexpensive materials, easily obtained.
15

16 17 18 19 20 *Plant invasion questionnaire*

21
22 About one year after the workshop, a questionnaire was prepared aiming to evaluate the
23
24 long-term efficacy of the workshop based on the knowledge retained by the students.
25
26 The questionnaire was distributed to the students who participated in the workshop and
27
28 to students from the same schools and the same age range (13-15 years old), but that did
29
30 not participate in the workshop. The latter worked as a control group.
31

32
33 The questionnaires (**Annex 1**) consisted of four pages with a total of 10
34
35 questions. The first two pages had nine close-ended questions about definitions of
36
37 native, exotic and invasive plants, problems associated with invasive plants and most
38
39 efficient control methods. The other two pages included one single question with the 16
40
41 pictures of native and invasive plants that were presented at the workshop, and students
42
43 were asked to write the common or scientific name of each plant and to indicate if the
44
45 plant was native or invasive in Portugal.
46

47
48 A total of 340 questionnaires were sent to the participant schools and 150
49
50 questionnaires were responded, 68 (45.3%) from students that attended the workshop
51
52 one year earlier, and 82 (54.7%) from students that did not attend the workshop. The
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1
2 questionnaires from participant students were answered by 30 girls and 38 boys, and the
3
4 average age was 14.7 years old. The questionnaires from non-participant students were
5
6 answered by 46 girls and 36 boys and the average age was 13.6 years old.
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10 11 *Data analyses*

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14 The responses provided by participant and non-participant students in the workshop
15
16 were analyzed using analysis of variance (1-way ANOVA) after confirming the
17
18 assumption of homogeneity with the Bartlett test. Statistical analyses were carried out
19
20 using STATISTICA 6.0.
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26 **3. Workshop Activities**

27 28 *Activity 1 - Competing for Resources*

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31 This game was adapted from Vieira (2002), with some modifications. The activity was
32
33 performed in a large indoor area, but it can also be carried out outdoors. For a group of
34
35 12 students the materials used were: a rope of about 3 m to mark the starting point; 11
36
37 arcs of about 50 cm diameter or same size circles made with rope; 36 paperboard
38
39 resource cards: 11 WATER, 11 LIGHT and 11 NUTRIENTS; 12 arm or bracelet
40
41 ribbons with the word INVADER.
42
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45 Two different paths starting and ending together were set: one linear, direct path
46
47 and one longer path, with several obstacles in the way. Along the way, the paths join in
48
49 three intermediate points, where the resource cards were placed. At the end of both
50
51 paths, there were ropes in circle placed on the floor. The number of ropes was equal to
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1
2 the number of students playing as native species in the beginning of the activity (11)
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4 **(Figure 1)**. The shorter path was used by students representing invasive plants (a ribbon
5 with the word INVADER was used in the arm to identify these students) and the longer
6 path was used by students representing native plants. The cards represented the
7
8 resources needed for plants to live. The circular ropes represented the plant *habitat*.
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16 [Insert Figure 1 here]
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21 The activity was played in several rounds, the first one starting with only one
22 invasive plant and all other students representing native plants. All students began to
23 walk at the same time from the starting point, each group going through their
24 correspondent path, invasive or native. Along the way, each student had to collect one
25 card of each resource, reaching their place in one *habitat*; only students with the three
26 resource cards could occupy a place in the *habitat*. The number of available cards was
27 not enough for all the students. Since the student playing as invasive plant followed an
28 easier path, he/she was the first to collect all the three cards and to reach a place in the
29 *habitat*. Students playing as native plants would have to follow the longer path and it
30 could happen that some of the resource cards were not available to collect.
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42 At the end of the first round, one or more native students, depending on the
43 resource cards distribution, could not take place in one *habitat* since they did not have
44 all the resources needed to live. For instance, if only one of each resource cards had
45 been removed, all students but one had all cards and reached a place in the habitat. The
46 discussion was encouraged by asking questions like: “*What happened to this native*
47 *plant? Why did not it get the resources needed for survival? Who took the resources*
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2 *that were previously available? Why have the invasive plant used more resources?*
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4 *Where the invasive plant came from?"* were asked. But if three light cards or/and two
5
6 water cards were removed, at the end of the round several students could not enter the
7
8 habitat since they did not have all the three resources necessary. In this case, questions
9
10 like: "*Why cannot these native plants live? Can they live only with food? Who took the*
11
12 *water/light that they need? Why is the invasive plant population growing so rapidly?*
13
14 *What is happening to the native plants?"* could be asked.

15
16
17 On the next round, students that did not achieve one *habitat* would play the
18
19 game as invasive species. The activity went on, and before each round one or more
20
21 resource cards were removed, in a way that resources were not enough for all the
22
23 players. At the end of each round, the students that could not collect the three resource
24
25 cards were identified as invasive species and in the next round walked along the easier,
26
27 shorter path. By the fourth or fifth round more students were playing as invasive plants
28
29 than as native plants. At the end of the game, when only two or three students were
30
31 acting as native plants, the questions addressed were: "*What happened to the native*
32
33 *plants? What could happen to the native plants if we keep playing the game? How did*
34
35 *the introduction of only one invasive plant affect the ecosystem?"*

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37
38 If no large space is available this activity can also be adapted to a small area like
39
40 a classroom. Instead of having one shorter and one longer path, both paths can have the
41
42 same length, but students acting as invasive plants can have barriers, like seats to cross
43
44 over or a table to cross under, or can walk on one foot or inside a fabric bag.

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49 *Activity 2 - Invading, Inventorying and Controlling*
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2 This activity was adapted from Weed Invasion Website (2010), with some
3
4 modifications. It was performed in an indoor space of about 9 m², but can also be
5
6 adapted to outdoors. For a group of 12 students the materials used were: 25 paperboard
7
8 plant leaves with different shapes and colours (except green); 250 paperboard green
9
10 leaves with the shape of a well-known invasive species (*Acacia longifolia* shaped leaves
11
12 were used since it is a widespread invasive species along the Portuguese coast); 12
13
14 ropes with 2.5 m (four to make the ecosystem borders and eight to make the transects);
15
16 tape-measure; two tweezers; two water sprinklers; two small brooms and spades. A
17
18 cardboard was used to annotate data from inventories.

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20
21 The activity aimed to simulate the evolution of one ecosystem during its
22
23 invasion by an invasive plant species and finally the attempt to control the invader.
24
25 Before starting the activity, students were divided into three groups; four students for
26
27 the “invading group”, two students for the “inventorying group” and six students for the
28
29 “controlling group”.

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32 The first group started by “constructing” the ecosystem with four ropes, limiting
33
34 a square, and distributing the leaves of native plants all over the ecosystem (**Figure 2A**).
35
36 Then, they searched for the leaves of the invasive plant (*A. longifolia*) that were hidden
37
38 in a more distant place of the Museum, simulating a trip to Australia (native range of *A.*
39
40 *longifolia*), from where they brought seeds of *A. longifolia* that rapidly invaded the
41
42 ecosystem (**Figure 2B**). During the construction and the invasion of the ecosystem, in
43
44 order to stimulate the discussion, students were asked questions like: “*How can the*
45
46 *invasive plant get here? Why is the invasive plant population so big? How is the*
47
48 *diversity of the native plants compared to the invaded community? What happened to*
49
50 *the native plants after the arrival of the invasive plants?*”
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5 [Insert Figure 2 here]
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10 The second group was responsible for the inventory activity of the plants
11 existing in the ecosystem, and allowed students to act as field biologists. Firstly,
12 transects were placed 50 cm apart from each other, both parallels and perpendiculars,
13 forming 50 cm squares, using ropes with help of the tape-measure (**Figure 2C**).
14 Secondly, students choose four or five parcels to make inventories, counting all the
15 plants present inside each parcel, native and invasive. Students were asked to select the
16 parcels that better represented the number and proportion of the plants in the entire
17 ecosystem. The concept of representative parcels was, for most of the students, difficult
18 to understand, but at the end of the activity, when students were informed of the total
19 number of native and invasive leaves distributed (25 native leaves and 250 invasive
20 leaves were distributed in the 2,5 m² ecosystem, divided in 25 parcels) almost all
21 students could easily decide on the parcel that had the closest proportional number of
22 native and invasive plants in relation to the entire ecosystem. Questions like: *“Is it easy
23 to perform inventories in large areas? Is the inventory on only one small parcel enough
24 to obtain representative results? What could be done to achieve the closest
25 representative result?”* were asked to encourage debate.
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43 The third group removed the ropes used to build transects, leaving only two
44 ropes in order to divide the ecosystem in three rectangular parcels. Students were
45 divided into three groups of two, and each group was responsible for controlling the
46 invasive plants presented in one parcel in 45 seconds using different control methods:
47 manual control, represented by the tweezers (**Figure 2D**); mechanical control,
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2 represented by brooms and spades (**Figure 2E**) and chemical control, represented by
3 water sprinklers (**Figure 2F**). At the end, the advantages and disadvantages of each
4 control method were discussed questioning the students: “Which control method was
5 more efficient? Does this method have disadvantages? Is there any method that does not
6 have disadvantages and is totally effective? What happened to the native plants in each
7 of the control methods? Is there any control method for invasive plants that does not
8 affect native plants? How would you classify this method in terms of efficiency for
9 controlling invasive plants? Do herbicides affect only the invasive plants? After the
10 control actions, the ecosystem is free of invasive plants? What about the re-sprouts and
11 the seeds on the soil? Would it be enough to perform only one control treatment?”. The
12 discussion allowed students to better understand the message underlying the activity.
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25 In smaller areas or for smaller groups this activity can be adapted by building the
26 ecosystem on a table, using smaller leaves and the control methods can also be replaced:
27 the tweezers remain for manual control, small dropping-bottles can be used for chemical
28 control and tooth-brushes can represent mechanical control.
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36 *Activity 3 - Recognizing native and invasive plants*

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39 Students were invited to watch a series of 16 pictures that included native and invasive
40 plant species in Portugal. Firstly, pictures were shown for 30 seconds with both
41 scientific and common names depicted, and with the indication of the invasive or native
42 status. Afterwards the same pictures were presented, following a different sequence and
43 with no information given. The students were asked to name the plant and if it was
44 native or invasive in Portugal. The game was played with several teams that responded
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2 on turn, when one team gave the wrong answer, another could respond, creating a
3
4 competitive dynamic interaction, enthusiastically received by the students.
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7 The “Recognizing native and invasive plants” activity confirmed that the
8
9 knowledge of students about plants in general was low. Even emblematic native
10
11 species, protected by law in Portugal like English Holly (*Ilex aquifolium*)(Decreto-Lei
12
13 n.º 423/1989) or cork oak (*Quercus suber*, Decreto-Lei n.º 169/2001) were misidentified
14
15 or referred as invasive or exotic; on the contrary, some of the most common invasive
16
17 species (e.g. *Acacia dealbata*) were identified as native to Portugal.
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20 In the end, students were offered printed documentation about invasive plants
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22 that included a few basic concepts and a website where they could search for more
23
24 information.
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29 **4.Results**

30 *Invasive plant species workshop*

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33 During the workshop students had the opportunity to learn key concepts about invasive
34
35 plants on the brief introductory talk, and particularly on the practical activities that were
36
37 developed. In general, participants managed to answer the questions and understand the
38
39 concepts that were intended to transmit through the activities. Especially the students
40
41 from the 8th grade could integrate the new concepts with concepts learned during
42
43 biology classes, namely ecosystem, population and food webs.
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47 Students were engaged in the games from the beginning. The dynamics used
48
49 were well received and understood by the students and teachers, and the themes exposed
50
51 in the initial presentation were further explored and perceived. The way discussion was
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2 promoted by the monitors, asking several questions to the students during the
3
4 development of the activities, stimulated the students to think in order to reach their
5
6 own answers and conclusions. At the end of the session, the perception of the students
7
8 concerning invasive species had improved considerably and they were challenged,
9
10 together with the teachers, to organize activities about biological invasions in their
11
12 schools.

13 14 15 16 17 18 *Plant invasion questionnaire*

19
20 The results from the questionnaires were analyzed in order to evaluate the concepts
21
22 acquired about the invasive plant thematic by students that participated in the workshop.
23
24 In addition, responses from these students were compared with responses from students
25
26 that did not participate in the workshop.
27

28
29 Definition of native species was considerably well known by both groups of
30
31 students, participants and non-participants, but uncertainty is still common when
32
33 students are asked to distinguish exotic and invasive plants. All questions - concerning
34
35 definitions, synonyms or differences between native, exotic and invasive plant species -
36
37 were answered more correctly by students that participated in the workshop (**Table 1 –**
38
39 **questions 1, 2 and 3**).

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44 [Insert Table 1 here]
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2 Students were also asked about the number of invasive plant species present in Portugal.
3
4 This was one of the few questions where the percentage of correct responses was
5
6 statistically similar amongst non-participant and participant students (**Table 1 –**
7
8 **question 4**). Possibly, because students were not able to remember the exact number
9
10 they responded randomly. However, all students who participated in the workshop and
11
12 gave a wrong answer to this question chose the highest value given as hypothesis (400),
13
14 which suggests that these students got the idea that the presence of invasive plants is in
15
16 fact a big problem that cannot be underestimated.
17

18
19 During the workshop, it was explained how plant species arrive to the exotic
20
21 range and why they became invasive there. One year after, students that attended the
22
23 workshop were more capable to choose the most complete answer about this issue by
24
25 comparison with non-participant students (**Table 1 – question 5**). The percentages
26
27 shown represent the value of the only absolutely correct answer from the five
28
29 hypotheses given. Many students gave uncompleted answers by choosing only one of
30
31 the three partially correct options, but even in this case significant differences could be
32
33 found between the two groups of students: 47.6% for non-participants against 30.9% for
34
35 participants in the workshop.
36

37
38 Students were asked about the Portuguese legislation concerning the
39
40 introduction of exotic species in nature. The question was presented to the students with
41
42 a “yes” or “no” answer, which could influence the response, namely helping the non-
43
44 participant students. However, significantly more students that participated in the
45
46 workshop knew about the law than non-participant students (**Table 1 – question 7**),
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48 showing that this was one of the messages that students retained from the workshop.
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2 Advantages and disadvantages of three of the most common control methods of
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Advantages and disadvantages of three of the most common control methods of invasive plant species were discussed in the “Invading, Inventorying and Controlling” activity. In the questionnaire, students were asked to choose the most complete response concerning control among five, being three incomplete, one wrong and one complete. Differences between participants and non-participant students were not statistically significant, although there is a tendency for a better understanding of the concepts concerning invasive plant species by the participant students (**Table 1 – question 8**).

When students were asked to indicate the environmental problem that could be caused by invasive plant species (**Table 2– question 6**), less than 7.4% of the participant students identified problems that were not directly caused by invasive plants (increase of CO₂ level, sea level rise and increase of air pollution), but many more non-participant students selected them. Problems such as biodiversity loss, changes in food-webs, decrease of available resources for native plants and high costs in control actions, all referred several times in the talk and practical activities in the workshop, were mainly identified by participant students.

[Insert Table 2 here]

When students were asked to mark the most effective measure to avoid proliferation of invasive plant species, considerable differences were found between participants and non-participant students (**Table 3 – question 9**). Most non-participant students selected only one of the measures in opposition to all three measures selected by the majority of participant students. Control was the main selected measure chosen

1
2 by participant students, probably due to the importance given to the subject in the
3
4 workshop. Non-participant students have chosen control and inspection equally.
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10 [Insert Table 3 here]
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15 The same pictures of native and invasive species used in the activity 3 of the
16 workshop were presented to the students in the questionnaire. Students were asked to
17 indicate if each species was native or invasive in Portugal and additionally to identify
18 their common or scientific name, both being accepted if correct. Ten species (5 native
19 and 5 invasive) were recognized by more than 50% of the participant students, while
20 only 4 native species were recognized by more than 50% of the non-participants (**Table**
21 **4 – question 10**). Significant differences in species recognition were found between
22 participant and non-participant students for almost all invasive species (exception for
23 *Ailanthus altissima*), while for native species differences were only found for *Ilex*
24 *aquifolium*, a species that is particularly emblematic for Christmas time and is protected
25 by the Portuguese law.
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46 Identification (specifically being able to attribute a name) of plant species proved to
47 be particularly difficult both for participant and non-participant students. The
48 percentage of students who correctly named the species was very low in both groups
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2 and the only species that were correctly identified by more than half of the students
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4 were all native (*Olea europaea*, *Quercus suber*, *Quercus robur* and *Ilex aquifolium*).
5
6 However, some significant differences between the two groups were found and all
7
8 concerned invasive species (*Ipomoea acuminata*, *Ailanthus altissima*, *Acacia dealbata*
9
10 and *Eichhornia crassipes*), more effectively identified by participant students (**Table 4 –**
11
12 **question 10**).

13 14 15 16 17 18 **5. Discussion**

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20 The importance of public awareness about invasive species and the implications it can
21
22 have on public participation in environmental conservation have been reported in
23
24 several studies, although mainly with adult public (Bremner and Park, 2007; Fisher and
25
26 van der Wal, 2007), local authorities (Kowarik and Schepker, 1998), or stakeholders
27
28 (García-Llorente *et al.*, 2008). Well-informed public will understand the need of
29
30 developing management projects of wildlife protection. Bremner and Park (2007)
31
32 highlighted the importance of those involved in invasive species management to engage
33
34 directly with the public, explaining and showing the need for habitat conservation. If the
35
36 appropriate involvement is provided, public will happily and voluntarily learn about
37
38 what they can do to prevent invasive species and participate in the activities promoted to
39
40 control these species (Marchante *et al.*, 2008b).

41
42
43 After developing diverse initiatives to enhance public awareness about invasive
44
45 plant species (Marchante *et al.*, 2008b), we thought it would be important to develop the
46
47 workshop “Invasive Plant Species – What are they? Where do they come from? Which
48
49 problems do they cause?” particularly for young students. This was one of our first
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51 initiatives targeting non-adult publics and the results of the questionnaire clearly
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2 showed that it is worthwhile continuing to promote education and awareness on
3
4 invasive species for this particular audience. Targeting young students contributes to
5
6 prepare generations of citizens who have a more active and positive attitude towards
7
8 nature conservation and in this case invasive species. As shown by the results of the
9
10 questionnaire, this two hours workshop contributed to an increase of knowledge of the
11
12 participants that lasted at least one year after they participated in the activities.
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15 The observed low ability to recognize and identify plant species among students is not
16
17 unique for this particular age group neither for Portuguese students, since the
18
19 knowledge of students about identification of plants is equally low in other countries
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21 (Bebbington, 2005; Strgar, 2007; Schussler and Olzak, 2008). This inability was also
22
23 observed when students were asked to distinguish between native and invasive plants.
24
25 In Portugal, not only general population but even publics that deal with exotic plants are
26
27 sometimes not aware of this environmental problem (Marchante&Marchante, personal
28
29 communication; <http://www.uc.pt/invasoras>). A recent questionnaire from
30
31 Eurobarometer (The Gallup Organization, 2010) showed that only 1% of the inquired
32
33 Portuguese population considered invasive species to be the most important threat to
34
35 biodiversity.
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38 In this context, it was very important to start this workshop with the basic
39
40 concepts and to show examples of some of the worse invasive plants in Portugal, and
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42 results showed that part of that information was retained by students one year later. The
43
44 practical activities used proved to be very well adapted to the target public, making it
45
46 very easy to engage the students in understanding the basic concepts and problems
47
48 involved. In general, students easily answered the questions asked during the activities,
49
50 showing that concepts were acquired. In some cases, students were even able to extend
51
52 the discussions by relating known concepts with the recently acquire knowledge.
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2 Although IAS is only briefly discussed in school curricula, during the two practical
3 activities students were confronted with terms that were familiar to them like *habitat*,
4 ecosystem, food web and they were able to related them to the particular case of
5 IAS. Teachers involved were also very enthusiastic about the activities, considering
6 them well adapted to the students' level and curricula.
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13 The three practical activities, together with the introductory talk, complemented
14 each other and allowed students to understand subjects such as biological invasion
15 process, impacts of invasive species, ecosystem recovery and resilience, and difficulties
16 to control invasive species. Furthermore, students could see the importance of their
17 involvement in both prevention and control of invasive plants. This was achieved by
18 creating activities where the involvement of the students was very high, and key-
19 information was acquired during the different practical activities instead of being
20 transmitted only theoretically. During the practical activities, students had the chance of
21 acting as native or invasive plants, or as biologists or environmental managers, which
22 allowed them to be familiar with the problems associated with the plant invasions from
23 different points of view.
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36 At the end of each session, both the organizers and the participants were very
37 pleased with the way the workshop was held. The activities developed showed that it is
38 worthwhile to invest in public education and awareness, since it helps to prevent the
39 spread of invasive species. The workshop also showed that it is not difficult or
40 expensive to prepare practical activities that are interesting, making the most of basic
41 common used materials. The evaluation of the workshop assessed the knowledge
42 effectively acquired about the subjects discussed. In addition, the comparison of the
43 results with a control group was relevant to evaluate the knowledge about invasive plant
44 species by students in Portugal. Results showed that attending the workshop
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2 significantly increased the students' knowledge about invasive plant species. Biological
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4 invasion, being a relatively recent topic of concern, is not much acknowledged by
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6 school teachers, which reinforces the need to develop activities to increase public
7
8 awareness about this topic.
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11 An essential part of this work was the evaluation process itself. More than
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13 showing that student participating in the workshop knew more about invasive plants, it
14
15 is important to emphasize that evaluation of public awareness and environmental
16
17 education activities is essential. Frequently, funds available for communication and
18
19 public awareness are limited and therefore need to be used cost-effectively. To do that,
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21 effectiveness of activities and strategies need to be evaluated adequately, going further
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23 than asking to the participants if they enjoyed participating in the activities. Quite often,
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25 considerable investment is allocated on printing leaflets and other documentation which
26
27 are delivered to people without any further involvement or evaluation of their
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29 effectiveness in promoting changing of attitudes. We believe that leaflets and other
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31 documentation are important to inform the public, but ideally they should be used
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33 together with activities that engage the public, thus becoming more cost-effective.
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39 **6. Conclusions**

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42 The workshop about Invasive Plant Species showed that recognizing plants in general is
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44 not an easy task for Portuguese 13-15 years old students; additionally their knowledge
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46 about exotic and invasive plants is very limited. However, this study also showed that
47
48 teenager students, when attending engaging and well-developed activities, understand
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50 and actively retain the new information from subjects poorly explored in the school
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52 curricula. This fact was clearly showed by the results of the questionnaire conducted
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2 after the workshop, and is even more relevant since the evaluation was only performed
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4 one year later, which validates the messages retained and the knowledge acquired. It is
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6 our understanding that the involvement of the students in the activities was also of
7
8 outmost importance, allowing them to execute, interpret, discuss and reach their own
9
10 conclusions. Although this was one of the first initiatives promoted by the research team
11
12 targeting non-adult publics, the results clearly show that it is worthwhile continuing to
13
14 promote education and awareness on invasive species for this particular audience.
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21
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23
24 the University of Coimbra for all their help in the preparation of the workshop on
25
26 Invasive Plant Species. Special thanks are also addressed to all the students and teachers
27
28 who participated in the workshop “Invasive Plant Species – What are they? Where do
29
30 they come from? Which problems do they cause?”. This workshop was supported by
31
32 FCT-MCTES (Portuguese Foundation for Science and Technology) and European fund
33
34 FEDER, project INVADER II - Invasion processes, control and restoration of coastal
35
36 ecosystems invaded by *Acacia longifolia* -PPCDT/AMB/61387/2004.
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42 **Web link**

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44 Website developed by researchers of the Centre for Functional Ecology of University of
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46 Coimbra (CEF) and Centre of Studies for Natural Resources, Environment and Society
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48 of Agrarian School of Coimbra (CERNAS) about Invasive plant species in Portugal:
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50 <http://www.uc.pt/invasoras>
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47 **Figure 1.** Schematic representation of the material distribution in the activity

48 “Competing for Resources”.— Path for students playing as invasive plants; --- Path for
49 students playing as native plants; ○ (habitats).

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5 **Figure 2.** Images showing several steps of the activity 2 “Invading, Inventorying and
6 Controlling”: A – Creating the ecosystem with native plants; B – Simulating plant
7 invasion; C – Setting transects for inventory; D – Manual control, with tweezers; E –
8 Mechanical control, with brooms and spades; F – Chemical control, with water
9 sprinklers.
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17 **Table 1** – Percentage of correct answers given by participant and non-participant
18 students of the workshop about invasive plants (answers to questions 1 to 5, 7 and 8 of
19 the questionnaire).
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25 **Table 2** – Problems that students believed to be caused by invasive plants (answers to
26 question 6 of the questionnaire).
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31 **Table 3** – Most effective measures to prevent spread of invasive plant species (answers
32 to question 9 of the questionnaire).
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37 **Table 4** – Percentage of participant and non-participant student that recognized and
38 named native and invasive plants correctly (answers to question 10 of the
39 questionnaire).
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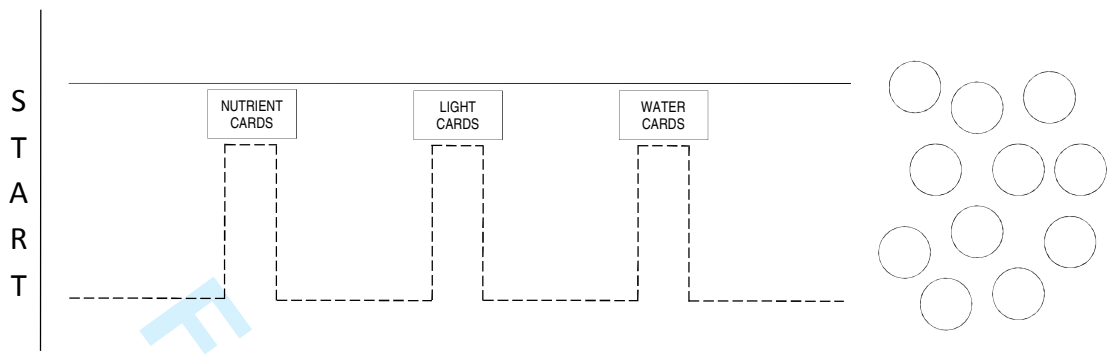


Figure 1

For Peer Review Only



Figure 2

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Table 1

Questions	Participants	Non-participants	Significance (p)
1. Synonyms of native plant	57.4 %	39.0 %	0.0252
2. Differences between invasive and exotic species	76.5 %	61.0 %	0.0432
3. Definition of native plant	80.9 %	62.2 %	0.0121
3. Definition of exotic plant	44.1 %	24.4 %	0.0105
3. Definition of invasive plant	44.1 %	28.1 %	0.0407
4. Number of invasive plant species reported in Portugal	39.7 %	51.2 %	n.s.
5. How invasive plants arrive to Portugal	38.2%	6.1%	0.000
7. Existence of legislation for the introduction of non-native species in Portugal	73.5 %	45.1 %	0.0004
8. Best approach for controlling invasive species	48.5 %	35.4 %	n.s.

Table 2

Problems	Participants	Non-participants	Significance (p)
Biodiversity loss	60.3%	29.3%	0.0001
Reduction in agricultural productivity	55.9%	53.7%	n.s.
Increase of CO ₂ level	7.4%	35.4%	0.00003
High economic costs in control actions	61.8%	40.2%	0.008
Sea level rise	2.9%	7.3%	n.s.
Public health problems such as allergies	72.1%	59.8%	n.s.
Landscape scenery change	80.9%	68.3%	n.s.
Increase of erosion problems	10.3%	18.3%	n.s.
Changes in water resources	19.1%	25.6%	n.s.
Increase of air pollution	1.5%	15.9%	0.002
Changes in food-webs	67.6%	36.6%	0.0001
Decrease of available resources for native plants	82.4%	63.4%	0.009

Table 3

Measures	Participants	Non-participants	Significance (p)
Awareness	66.2%	42.7%	0.004
Control	80.9%	59.8%	0.005
Inspection	67.6%	59.8%	n.s.
Only one measure selected	27.9%	50%	0.006
Only two measures selected	13.2%	6.1%	n.s.
All three measures selected	54.4%	32.9%	0.008
Incorrect or Unanswered	4.5%	11%	n.s.

Table 4

Species	Recognizing native and invasive plant species			Naming native and invasive plant species		
	Participants	Non-participants	Significance (p)	Participants	Non-participants	Significance (p)
<i>Acacia longifolia</i>	55.9 %	35.4 %	0.0117	8.8 %	2.4 %	n.s.
<i>Ipomoea acuminata</i>	47.1 %	17.1 %	0.0001	5.9 %	0.0 %	0.0260
<i>Ailanthus altissima</i>	47.1 %	37.8 %	n.s.	7.4 %	0.0 %	0.0123
<i>Arbutus unedo</i>	63.2 %	59.8 %	n.s.	36.8 %	42.7 %	n.s.
<i>Carpobrotus edulis</i>	41.2 %	20.7 %	0.0063	4.4 %	6.1 %	n.s.
<i>Lavandula</i> sp.	35.3 %	32.9 %	n.s.	14.7 %	19.5 %	n.s.
<i>Cistus ladanifer</i>	33.8 %	36.6 %	n.s.	1.5 %	0.0 %	n.s.
<i>Oxalis pes-caprae</i>	52.9 %	20.7 %	0.0000	2.9 %	4.9 %	n.s.
<i>Acacia dealbata</i>	72.1 %	39.0 %	0.0000	33.8 %	13.4 %	0.0028
<i>Eichhornia crassipes</i>	48.5 %	19.5 %	0.0001	5.9 %	0.0 %	0.0260
<i>Olea europaea</i>	79.4 %	65.9 %	n.s.	63.2 %	62.2 %	n.s.
<i>Quercus suber</i>	79.4 %	65.9 %	n.s.	61.8 %	53.7 %	n.s.
<i>Cortaderia selloana</i>	69.1 %	35.4 %	0.0000	10.3 %	13.4 %	n.s.
<i>Quercus robur</i>	63.2 %	61.0 %	n.s.	48.5 %	63.4 %	n.s.
<i>Ilex aquifolium</i>	70.6 %	42.7 %	0.0005	67.6 %	67.1 %	n.s.
<i>Tradescantia fluminensis</i>	54.4 %	20.7 %	0.0000	7.4 %	8.5 %	n.s.

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4 5. How did invasive plant species arrive to Portugal? Choose the most complete answer:

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- they were brought to be used as ornamental plants
 - they came by accident, mixed in seeds and cereals
 - they were introduced for specific reasons as fixing littoral sand or drying humid soils
 - all of the options listed above are correct
 - none of the options listed above are correct

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13 6. From the problems listed mark the ones that can be caused by invasive plant species:

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- biodiversity loss
 - reduction in agricultural productivity
 - increase of CO₂ level
 - high economic costs in control actions
 - sea level rise
 - public health problems such as allergies
 - landscape scenery changes
 - increase of erosion problems
 - change of water resources
 - increase of air pollution
 - changes in food webs
 - decrease of available resources for native plants

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33 7. Is there a specific legislation concerning the introduction of non-native plants in Portugal?

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- Yes
 - No

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39 8. Which of the following statements do you consider more correct:









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- manual control is the most effective since it allows to carefully select the invasive plant species that need to be eliminated.
 - chemical control is the most effective since it rapidly eliminate only invasive plant species.
 - mechanical control is the most effective since it removes invasive plant species without damaging native plants.
 - all controls are effective since in one action they eliminate all invasive plants species.
 - ideally an integrated control (combination of several control types) should be used, always assuring several continuing controls

51
52 9. From the following measures mark the one you think is the most effective to avoid proliferation of
53 invasive plants:

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- public awareness activities about invasive plants species
 - control actions to eliminate invasive plants
 - inspection actions in the ornamental plants industry
 - all the actions listed above are important
 - none of the actions listed above are important

10. For each plant image identify its name and point out if it is native or invasive in Portugal

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 <p>Name <u>Acacia longifolia</u></p> <p><input type="checkbox"/> native <input checked="" type="checkbox"/> invasive</p>	 <p>Name <u>Ipomoea acuminata</u></p> <p><input type="checkbox"/> native <input checked="" type="checkbox"/> invasive</p>
 <p>Name <u>Ailanthus altissima</u></p> <p><input type="checkbox"/> native <input checked="" type="checkbox"/> invasive</p>	 <p>Name <u>Arbutus unedo</u></p> <p><input checked="" type="checkbox"/> native <input type="checkbox"/> invasive</p>
 <p>Name <u>Carpobrotus edulis</u></p> <p><input type="checkbox"/> native <input checked="" type="checkbox"/> invasive</p>	 <p>Name <u>Lavandula sp.</u></p> <p><input checked="" type="checkbox"/> native <input type="checkbox"/> invasive</p>
 <p>Name <u>Cistus ladanifer</u></p> <p><input checked="" type="checkbox"/> native <input type="checkbox"/> invasive</p>	 <p>Name <u>Oxalis pes-caprae</u></p> <p><input type="checkbox"/> native <input checked="" type="checkbox"/> invasive</p>

 <p>Name <u>Acacia dealbata</u></p> <p><input type="checkbox"/> native <input checked="" type="checkbox"/> invasive</p>	 <p>Name <u>Eichhornia crassipes</u></p> <p><input type="checkbox"/> native <input checked="" type="checkbox"/> invasive</p>
 <p>Name <u>Olea europaea</u></p> <p><input checked="" type="checkbox"/> native <input type="checkbox"/> invasive</p>	 <p>Name <u>Quercus suber</u></p> <p><input checked="" type="checkbox"/> native <input type="checkbox"/> invasive</p>
 <p>Name <u>Cortaderia selloana</u></p> <p><input type="checkbox"/> native <input checked="" type="checkbox"/> invasive</p>	 <p>Name <u>Quercus robur</u></p> <p><input checked="" type="checkbox"/> native <input type="checkbox"/> invasive</p>
 <p>Name <u>Ilex aquifolium</u></p> <p><input checked="" type="checkbox"/> native <input type="checkbox"/> invasive</p>	 <p>Name <u>Tradescantia fluminensis</u></p> <p><input type="checkbox"/> native <input checked="" type="checkbox"/> invasive</p>

Thank you very much for your collaboration.

For more information on Invasive Plants in Portugal go to www.uc.pt/invasoras